

UNIVERSITY OF DEBRECEN
Faculty of Engineering
Department of Mechanical Engineering



PROCEEDINGS OF THE
4th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING
(ISCAME 2016)

13-15 October, 2016
Debrecen, Hungary

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4th INTERNATIONAL SCIENTIFIC CONFERENCE ON
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PROCEEDINGS OF THE 4th INTERNATIONAL SCIENTIFIC CONFERENCE ON ADVANCES IN MECHANICAL ENGINEERING



CONTENTS

ANDOR Krisztián, LENGYEL András, KARÁCSONYI Zsolt, BELLOVICS Bertalan <i>Experimental, modelling and application of timber beams reinforced with carbon fibre</i>	1 - 11
ANTAL Tamás, SIKOLYA László <i>Thin-layer drying characteristics of plum during hybrid- and freeze-drying</i>	12 - 18
BACHRATÝ Michal, KRÁLIK Marian, TOLNAY Marián, TEKULOVÁ Zuzana <i>Evaluation of the impact of cutting fluids on the course of cutting forces during machining</i>	19 - 25
BÁNKI Dániel, JOBBIK Anita <i>Dynamic modeling of hydrocarbon reservoirs using finite difference methods and derivation of analytic formulae for easier forecasting</i>	26 - 31
BELÉNYI Alpár, GYENGE Csaba, ACHIMAS Gheorghe <i>Specific aspects concerning the damages of components from refrigerant system units</i>	32 - 39
BICZÓ Roland, KALÁCSKA Gábor <i>Composite friction materials of couplings</i>	40 - 45
BODZÁS Sándor <i>Manufacturing analysis of grinding technology of conical worm shaft</i>	46 - 52
BOHÁCS Gábor, RINKÁCS Angéla <i>Application of Industry 4.0 in the material handling</i>	53 - 56
BÓNOVÁ Lucia, BOHOVIČOVÁ Jana, HALANDA Juraj, IVAN Jozef, MEŠKO Marcel <i>Fundamental plasma processes in the next generation of combined PIII-hipims implantation and deposition technique</i>	57 - 63
BÖRÖCZ Péter <i>Evaluation of truck vibration levels for packaging testing purposes in Hungary</i>	64 - 69
BOTH Balázs, SZÁNTHÓ Zoltán, GODA Róbert <i>Objective draught comfort investigations in a single office model room</i>	70 - 76
BOTH FEHÉR Kinga <i>Heat transfer conditions in scraped surface heat exchangers</i>	77 - 83
CALISTRU Cătălin Nicolae, TIMOFTE Dan <i>Pendular systems a nonconventional interdisciplinary variable structure system</i>	84 - 90
CĂȘVEAN Marius, LATEȘ Daniel, CIOLOCA Flaviu <i>The design and realization of the MC manipulation structure for microfactories</i>	91 - 95
COROIAN Olimpia <i>Study on operating risks in diesel engines at 060-DA railway engine</i>	96 - 101



**PROCEEDINGS OF THE
4th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



CVETICANIN Livia, CVETICANIN Dragan <i>Theory of acoustic metamaterials</i>	102 – 108
CSAVAJDA Péter <i>Vibration testing in the evaluation of packaging performance</i>	109 – 114
CSICSÓ Tomáš, ŠVEC Pavol, DŘÍMAL Daniel <i>Effect of fibre laser welding on microstructure and microhardness of DP600-DP980 steel joints</i>	115 – 121
DEÁK Krisztián, KOCSIS Imre <i>Applied vibration measurement methods and data extraction for bearing fault diagnosis</i>	122 – 126
DEÁK Krisztián, KOCSIS Imre <i>Selection of wavelet function for detection of bearing defects by Shannon entropy</i>	127 – 134
DÓCS Roland, JOBBIK Anita <i>Additional problem overview of fluid flow in porous systems</i>	135 – 140
DÖMÖTÖR Ferenc, ÁCS János, SZÖRÉNYI Norbert <i>Application of on-line vibration monitoring in a rolling mill</i>	141 – 144
ĐORĐEVIĆ Branislav, TATIĆ Uroš, SEDMAK Simon, MILOŠEVIĆ Miloš, SEDMAK Aleksandar <i>Digital image correlation technique application on welded joint - advantages and disadvantages</i>	145 – 150
DOROGI Dániel, BARANYI László <i>Effect of gradual amplitude increase on flow around a cylinder oscillated in line</i>	151 – 156
DUDÁS László <i>Generation and analysis of a new hourglass-like worm gearing</i>	157 – 162
ENYEDI László <i>Dividing box from 10 to 210</i>	163 – 166
ERDÉLYI Viktor, JÁNOSI László <i>Smart livestock farming in the footsteps of industry 4.0</i>	167 – 172
FINŽGAR Miha, PODRŽAJ Primož <i>An insight into non-contact assessment of human skin microcirculation</i>	173 – 177
FLORESCU Virgil, CAPITANU Lucian, BADITA Liliana-Laura <i>Testing adhesion of the coating with thin layers by the inclined cyclic impact</i>	178 - 183
GÁBORA András, et. al. <i>Prototype battery electric car development for Shell Eco-Marathon competition</i>	184 – 186
GODZSÁK Melinda, LÉVAI Gábor, VAD Kálmán, CSÍK Attila, HAKL József, KULCSÁR Tibor, KAPTAY George <i>Hot-dip galvanizing in zinc-manganese bath</i>	187 – 194



**PROCEEDINGS OF THE
4th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



GYENGE Csaba <i>Main results of 50 years researches in the field of gear transmissions development</i>	195 - 206
HAGYMÁSSY Zoltán, PÁLINKÁS Sándor, GINDERT-KELE Ágnes <i>Examination of the fertilizer distributor using GPS guidance system</i>	207 – 210
AL-MALIKI Hayder, ZSIDAI László, KALÁCSKA Gábor, KERESZTES Róbert, SZAKÁL Zoltán <i>Friction tests of different polymer treated by plasma technology</i>	211 – 216
HEGEDŰS György <i>Computer aided product development of ball screw drive</i>	217 – 220
HÉGELY László, LÁNG Péter <i>Batch extractive distillation with off-cut and entrainer recycle</i>	221 – 227
LÁNG Péter, HÉGELY László, DÉNES Ferenc <i>Simulation of CO₂ absorption with different amine solvents</i>	228 - 233
HNILICOVÁ Michaela, CHROMEK Ivan, HNILICA Richard, DADO Miroslav <i>Design of adapter for fire fighting of forest fires</i>	234 – 240
HORVÁTH Csaba <i>Extended operating maintenance model for modern printing machines, new initiatives</i>	241 – 246
HURI Dávid, MANKOVITS Tamás <i>Incompressibility analysis of rubbers using FEM</i>	247 – 253
JOLDES Nicolae <i>Study of technical systems and of integrated waste management activities of processing and storing the municipal waste</i>	254 – 258
KÁLLAI Imre, HOLZWEBER Jürgen, MAJOR Zoltán <i>Test method for brittleness temperature of TPU elastomers by impact</i>	259 – 264
KARTUNOV Stefan, DRUMEV Krasimir, STOEVI Iliyan <i>Information technologies management system for medium-sized companies in mechanical engineering</i>	265 – 276
KATONA Bálint, SZEBÉNYI Gábor, ORBULOV Imre Norbert <i>Behaviour of metal matrix syntactic foams under cyclic loading</i>	277 – 282
KOMPOLŠEK Melita <i>An improved coarse-fine searching scheme for fast displacement measurement</i>	283 – 287
KOVÁCS Róbertné, KESZTHELYI-SZABÓ Gábor, SZENDRŐ Péter <i>Dielectric parameters of meat industry wastewater</i>	288 - 292
KUZMANOVIĆ Siniša, RACKOV Milan, VERES Miroslav <i>Analysis of requirements corresponding to development of modern products</i>	293 – 301



**PROCEEDINGS OF THE
4th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



LENGYEL Tamás, PUSZTAI Patrik, JOBBIK Anita <i>Innovative method for hydraulic fracturing optimization</i>	302 – 307
ĽUPTÁČIKOVÁ Veronika, ŤAVODOVÁ Miroslava <i>The effect of ambient temperature on parts dimensional control at repairing of locomotives combustion engines</i>	308 – 312
MÁJLINGER Kornél, BORÓK Alexandra, PASQUALE Russo Spena, VARBAI Balázs <i>Tig welding of advanced high strength steel sheets</i>	313 – 318
MARKOVA Kremena <i>The visual language of a form</i>	319 – 323
MÁTÉ Márton <i>A possible modeling of the constructive cutting geometry of the gear hobs</i>	324 – 329
MIKÁ CZÓ Viktória, SIMÉNFALVI Zoltán, SZEPESI L. Gábor <i>Investigation of deflector plates in case of gas explosion</i>	330 – 335
MOLNÁR András, FAZEKAS Lajos, CSABAI Zsolt, PÁLINKÁS Sándor <i>Properties of cold gas dynamic sprayed coatings</i>	336 – 346
MOLNÁR András, FAZEKAS Lajos, CSABAI Zsolt, PÁLINKÁS Sándor <i>Durability improveing of agricultural machines parts with hard coatings</i>	347 – 356
MORAUSZKI Kinga, LAJOS Attila <i>Methoden der Lieferantenauswahl in der Automobilindustrie in Ungarn</i>	357 – 368
NEMES Attila, MESTER Gyula <i>Energy efficient feasible autonomous multi-rotor unmanned aerial vehicles trajectories</i>	369 – 377
NÉMETH Géza, PÉTER, József <i>Design considerations of harmonic traction drives</i>	378 – 381
OLÁH Béla <i>The situation of maintenance services in agriculture</i>	382 – 388
PÁLINKÁS Sándor, FAZEKAS Lajos, GINDERT-KELE Ágnes, MOLNÁR András, HAGYMÁSSY Zoltán, KONYHÁS Dávid <i>Improvement of tillage elements of agricultural machinery</i>	389 – 395
PODRŽAJ Primož, SIMONČIČ Samo <i>Arc welding as a control system</i>	396 - 401
POKORÁDI László, DUER Stanisław <i>Investigation of maintenance process with Markov Matrix</i>	402 – 407
POÓS Tibor, VARJU Evelin, SEBESI Viktória, SZABÓ Viktor <i>Determination of drying rate at herbs drying with ambient air</i>	408 – 413
POÓS Tibor, VARJU Evelin <i>Determination of volume decrease and air velocity at herbs drying with ambient air</i>	414 – 419



**PROCEEDINGS OF THE
4th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



POÓS Tibor, SEBESI Viktória, VARJU Evelin, SZABÓ Viktor <i>Dimensionless evaporation rate at tubular artificial flow</i>	420 – 423
POP-SZOVÁTI Anton-Georghe, GYENGE Csaba, BORZAN Marian, POP-SZOVÁTI Jusztin Ágoston <i>Optimization methods of the drives for mechanical presses</i>	424 – 429
RÓNAI László, SZABÓ Tamás <i>Geometrically nonlinear modeling of a snap fitting process</i>	430 – 435
RUPPERT Tamás, ABONYI János <i>Cycle time adaptation of stochastic assembly line</i>	436 – 441
SARANKÓ Ádám, KERESZTES Róbert, KALÁCSKA Gábor <i>Machining of engineering polymers</i>	442 – 445
SÁRKÖZI Eszter, FÖLDI László <i>Genetic algorithm based parameter optimization of 3 control methods of pneumatic positioning system</i>	446 – 451
SÁROSI József <i>Influence of diameter and length on force developed by pneumatic muscle actuator</i>	452 – 457
ŠEBO Juraj <i>Optimization of disassembly of the products based on genetic algorithm</i>	458 - 462
SEDMÁK Simon, MILOVIC Ljubica, JOVICIC Radomir, DJORDJEVIC Branislav, DZINDO Emina, ZRILIC Milorad, MANESKI Tasko <i>Non-contact monitoring of fatigue crack growth via digital image correlation method</i>	463 – 468
SEFCIKOVA Miriam <i>Approach to development, measurement and evaluation the intellectual capital of the company in its industrial processes</i>	469 – 479
SIMONČIČ Samo, PODRŽAJ Primož <i>Modified inverse compositional algorithm for applications with significant lighting variations</i>	480 – 484
SKORIC Branko, MILETIC Aleksandar, TEREK Pal, KOVACEVIC Lazar, KUKURUZOVIC Dragan <i>Nano modification of hard coatings with ions</i>	485 – 490
SOÓS Noémi Rita, SOÓS Ödön János <i>Parameters and strategies that influence the quality of the mold surface in HSC process</i>	491 – 494
SOÓS Ödön János, SOÓS Noémi Rita <i>Design of a CNC router that can be mounted on an EDM equipment for on board electrode machining</i>	495 – 498
SPEISER Ferenc, ENISZ Krisztián <i>Optimization of mixed-flow grain dryers based on thermal analysis</i>	499 – 505



**PROCEEDINGS OF THE
4th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



STRAKA Luboslav, HAŠOVÁ Slavomíra <i>Optimalization of the preventive maintenance plan of technical equipments</i>	506 – 511
STRAKA Luboslav, HAŠOVÁ Slavomíra <i>Influence of dielectric fluid on the surface quality after die-sinking edm</i>	512 – 516
SUJOVÁ Erika, ČIERNA Helena <i>Improvement of selected processes on a production line</i>	517 – 522
SVOBODA Antonín, SOUKUP Josef <i>Stimulation of nerve path for medical use</i>	523 – 528
SZABÓ Viktor, POÓS Tibor, VARJU Evelin, SEBESI Viktória <i>Thermal modeling of a fluidized bed dryer</i>	529 – 534
SZAKÁL Zoltán, SCHREMPF Norbert, KORZENSZKY Péter, KARI-HORVÁTH Attila, PATAKI Tamás <i>Change in the mechanical properties of glass-reinforced vinyl ester resin under chemical effects</i>	535 – 540
SZIKI Gusztáv Áron, KISS János, SZÁNTÓ Attila, GÁL Tibor <i>Measurement of the electromagnetic and dynamic characteristics of a series wound DC motor</i>	541 – 544
TAKÁCS Annamária, GYURIKA István Gábor <i>Trends and developments on the surface- and edge quality of bioceramics</i>	545 – 550
TATIC Uros, DJORDJEVIC Branislav, SEDMAK Simon, VUCETIC Filip, ARANDJELOVIC Mihajlo <i>Technological and economic analyses of a different designs solutions of a pipeline supporting structure</i>	551 – 557
ŤAVODOVÁ Miroslava, KALINCOVÁ Daniela, SLOVÁKOVÁ Ivana <i>The comparison and evaluation of advantages and disadvantages between conventional and unconventional cutting of material</i>	558 – 564
TIBA Zsolt, FEKETE-SZŰCS Dániel <i>Recommendations for improving the precision of noise-measuring of rolling-contact bearings</i>	565 – 577
VARBAI Balázs, MÁJLINGER Kornél <i>Effects of high concentration hydrogen during GMA welding of duplex stainless steel</i>	578 – 583
VARGA Tamás Antal, KAPUSI Tibor <i>Digital image analysis of metal foam specimens</i>	584 – 587
KATONA Tamás János, VILIMI András <i>Design of severe accident management systems for Paks NPP</i>	588 – 596
VÖRÖSKŐI Kata <i>Packaging practices in automotive engine supply chains</i>	597 – 602



**PROCEEDINGS OF THE
4th INTERNATIONAL SCIENTIFIC CONFERENCE ON
ADVANCES IN MECHANICAL ENGINEERING**



SUPPORTING COMPANIES OF THE ISCAME 2016

Introduction of the companies

603 - 632

INTRODUCTION OF THE DEPARTMENT OF MECHANICAL ENGINEERING

633 - 636

PHOTO GALLERY OF THE ISCAME 2016 AND THE EXHIBITION

637 - 643



INNOVATIVE METHOD FOR HYDRAULIC FRACTURING OPTIMIZATION

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Abstract

As it is well-known, the well stimulation methods are getting more popular recently due to the increased significance of unconventional hydrocarbon resources. The hydraulic fracturing is one of the most frequently used treatments because of its large impact on the productivity index of the well. This paper presents a fracturing optimization algorithm which can be used effectively in evaluation period of the projects since it needs only the most important parameters of the given reservoir. This method provides both technical and economical optimization in hydraulic fracturing point of view. It is able to determine the most important fracking parameters which could provide the maximum NPV of the project with this algorithm.

Keywords: hydraulic fracturing, optimization, unconventional hydrocarbon, NPV

1. INTRODUCTION

The hydraulic fracturing is a multidisciplinary science, it needs very complicated engineering skills and in addition it is a quite expensive treatment therefore all effects should be considered in a fracking design procedure. It is obvious that the greater the treatment the greater the treatment's effect will be however there is a point considering the "size" of the treatment after that the profit resulted by the fracturing will be less than the costs of the procedure. Fig. 1 illustrates the NPV values of the fracking treatment as the function of the fracture half-length which is representing the size of the fracturing.

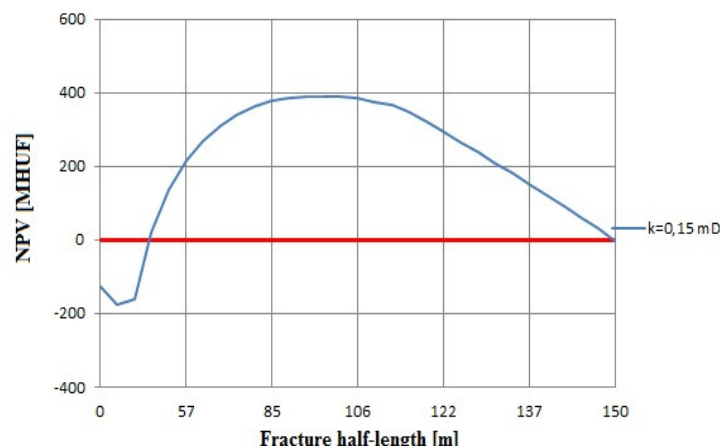


Figure 1 NPV of Treatment

Investigating the fracturing, a huge number of parameters might be taken into account. On one hand



it depends on which period of the project is actual, on the other hand how many data are available. As it was mentioned before this type of algorithm offers an optimization method in the early period of the project thus it integrates approximations, simplifications to be able to determine optimal parameters of fracturing. However a very important parameter was also integrated in the algorithm by which the application of the process was extremely extended. Well path is one of the most influencing parameter considering any kind of problem in petroleum engineering, therefore this optimization method can be applied also in case of vertical, deviated and horizontal wells providing diversification for the algorithm. As the results proved significant differences can be observed in variant cases.

2. MODEL

Considering the versatility and the complexity of the fracturing and the behaviour of several reservoirs, the operation of the algorithm was interpreted in relatively short range. However it must be emphasized that the process could be used for any kind of reservoirs and fluids with the necessary modifications. In the following the most important model properties are introduced.

Fracture geometry

The improved productivity of the well is closely related to the increased inflow surface which is in fact the fracture surface. Fracture opens always in the least resistance direction, in a given stress field fracture tries to propagate so as to avoid the greatest stress and it creates width in direction that requires the least force. It means that fracture propagates parallel to the maximum horizontal stress and perpendicular to the minimum horizontal stress. As the service companies, this model also assumes that fracture is created in the whole height of the layer. Fig. 2 represents the fracture geometry in vertical wells.

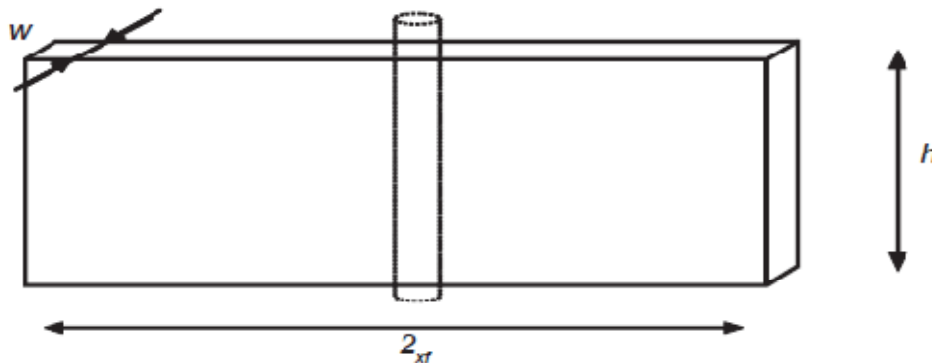


Figure 2 Fracture geometry in vertical well

Compared to vertical wells, fracture geometry in horizontal wells is completely different. Basically two types of fracture geometry can be defined in case of horizontal wells. If the well path is parallel to the maximum horizontal stress longitudinal fracture will be created, if the well is perpendicular to the maximum horizontal stress (parallel to the minimum horizontal stress) transverse fracture(s) will be created. In the longitudinal case, the fracture properties are the same as in the vertical well case. However the transverse fractures play a more significant role in the fracturing treatment. Although the inflow parameters of a transverse fracture are less favourable, this kind of treatment has the possibility to create more parallel transverse fractures (multi-fractured horizontal well) providing a significantly better inflow condition. Fig. 3 illustrates the fracture geometry in horizontal wells.

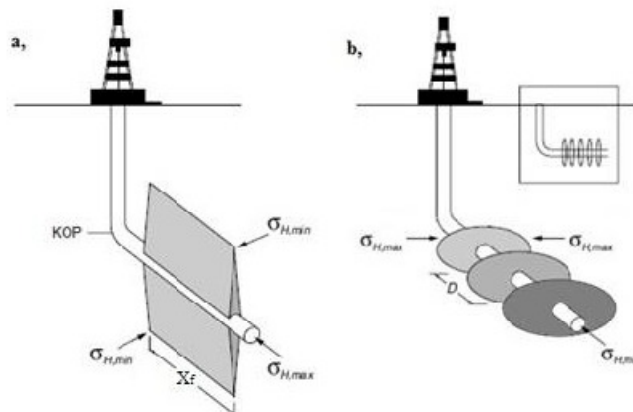


Figure 3 Fracture geometries in horizontal wells

According to the quite different fracture geometry in transversely fractured well several other effect has to be considered. Especially the limited contact area between the well and the reservoir that results a huge velocity increase in the inflow which requires another flow theory to consider correctly the flow.

Proppant distribution

One of the most important segment of fracking is the so-called proppant which propped the created fracture and provides a support not to collapse the fracture. Without going into details, the proppant distribution is a critical point considering the effectiveness of the treatment because it provides the conductivity of the flow pattern. The algorithm considers the proppant distribution on inhomogeneous way (as shown in Fig. 4) which makes the model much more realistic.

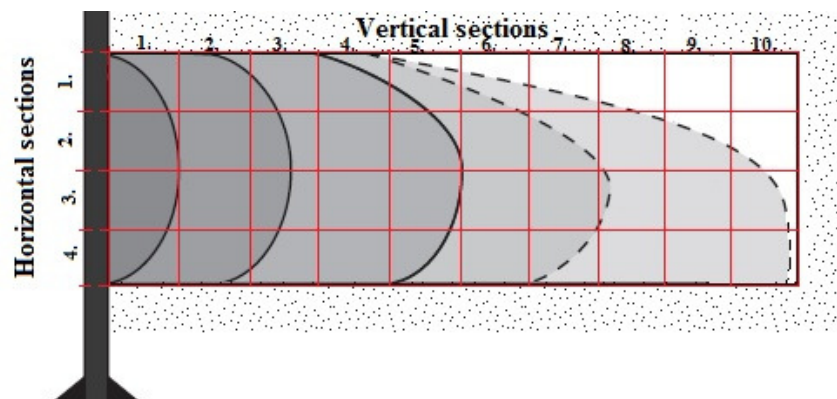


Figure 4 Proppant distribution

The cross section of the fracture is divided into vertical and horizontal cells thus the inhomogeneity due to the loss in proppant transport and the gravitational segregation can be considered as a proppant pack permeability decrease.

Other parameters

According to the high flow rates, the effect of turbulence has to be taken into account. This non-Darcy flow concept was also integrated into the algorithm as a separated small cycle. In addition in case of transversely fractured horizontal wells a choke skin effect was also considered due to the converging radial flow which results a significant drop in the flow rates.

To demonstrate the results on a relatively simple way, a closed dry gas reservoir was chosen. As the production is run, the reservoir pressure drops which results a production drop also in the flow rates considering a constant depression. A material balance equation was used to cope with this problem, Fig. 5 shows this perfectly.

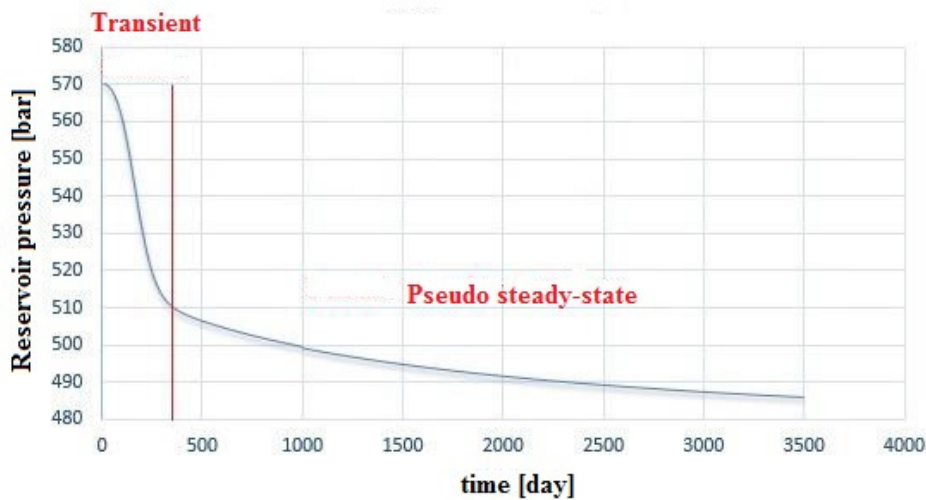


Figure 5 Pressure decrease in a closed reservoir

3. ALGORITHM

The optimization method presented in this paper is based on a multistage algorithm which includes main cycles. The main cycles contain more small cycles and calculations. The technical optimization is made by the so-called UFD (Unified Fracture Design) model which gives the maximum productivity indexes in function of the proppant masses. The economical optimization and the solution of other petroleum engineering problems are based on personal considerations. Table 1 summarizes the most important input parameters while Fig. 6 illustrates the operation of the algorithm with a flow chart, it symbolizes the main cycles of the algorithm.

Table 1 Input Parameters

Parameter	Symbol [dimension]	Parameter	Symbol [dimension]
Reservoir height	h [m]	Gas specific density	γ [-]
Reservoir permeability	k [mD]	Proppant pack permeability	k_f [mD]
Reservoir pressure	P_r [bar]	Proppant bulk density	ρ [kg/m ³]
Bottom hole pressure	P_{wf} [bar]	Original gas in place	G_i [nm ³]
Drainage area length	X_e [m]	Well radius	r_w [inch]
Reservoir temperature	T [K]	Crash factor	C_r [%]
Gas dynamic viscosity	μ [cP]	Treatment costs	$\$_t$ [MHUF]

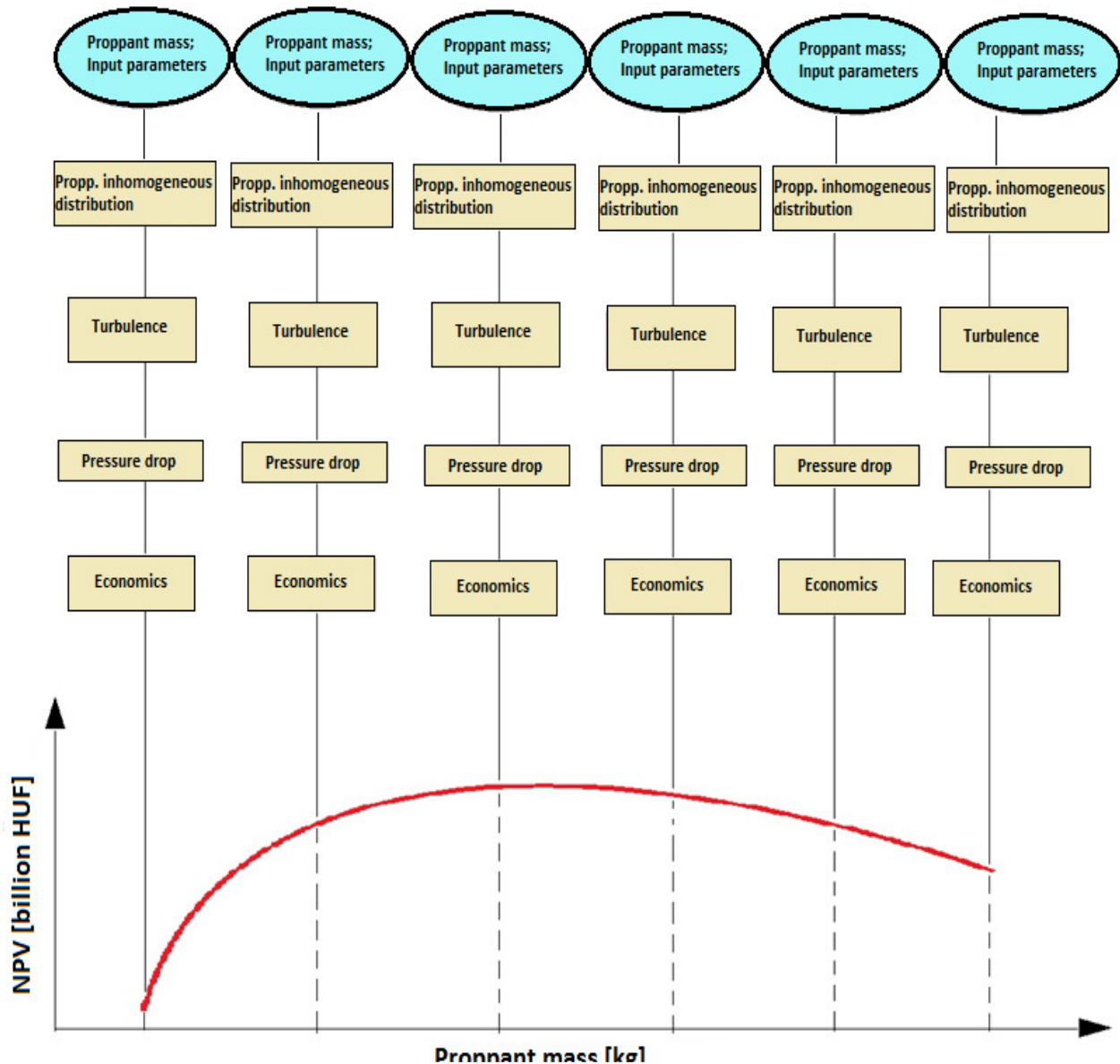
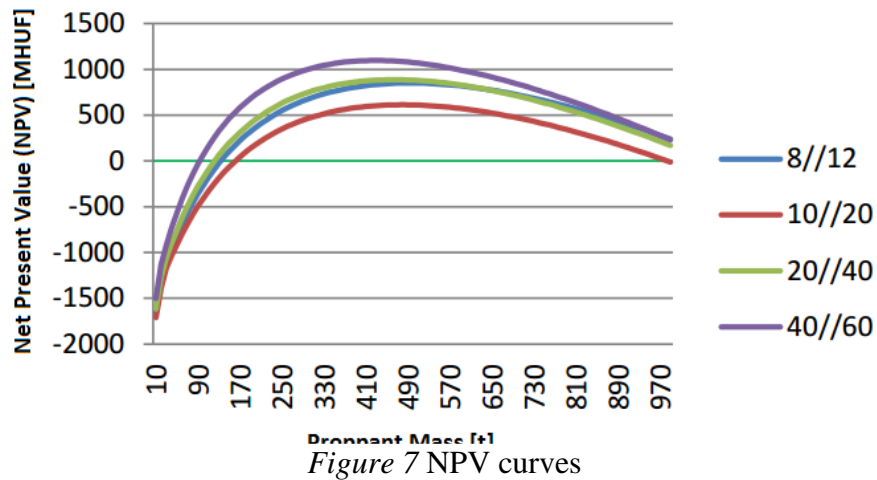


Figure 6 Flow chart

4. RESULTS

To show the operation of the optimization method, the algorithm was run with Hungarian input parameters which represent a typical tight gas reservoir in a Hungarian field. Different proppants were chosen to demonstrate the impact of proppant properties. Fig. 7 shows the NPV curves in function of proppant masses pumped down into a vertical well. As the flow chart illustrates (Fig. 6) the actual treatment parameters like fracture half-length, fracture conductivity, improved productivity index etc. can be also determined. In addition varying technical (fluid type, reservoir pressure and temperature, drainage area, well data, proppant size, OGIP or OOIP) and economical (drilling cost, treatment cost, CAPEX, OPEX) parameters sensitivity tests can be carried out and several significant and interesting effects can be concluded.



CONCLUSION

Applying the developed multistage algorithm fracturing projects can be prejudged and the profitability of the investment can be evaluated. With this method, the optimal treatment parameters can be determined. It also provides a kind of economical and technical optimization. In addition several types of sensitivity tests can also be conducted, thus the impact of technical (like proppant properties, reservoir parameters etc.) and economical (like gas or oil prize, OPEX, CAPEX) parameters can be investigated.

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REFERENCES

- [1] ADVANTI, S. H.–KHATTIB, H.–LEE, J. K.: Hydraulic Fracture Geometry Modeling, Prediction and Comparisons, In: paper SPE, 13863, 1985.
- [2] ECONOMIDES, Michael J.–MARTIN, Tony: Modern Fracturing. Enhancing Natural Gas Production, 2007.
- [3] LENGYEL, T.: *Horizontális kút hidraulikus rétegrepszítés optimalizálása*, Thesis, Miskolc, 2015.
- [4] PUSZTAI, P.: *Ferdített kút hidraulikus rétegrepszítés optimalizálása*, Thesis, Miskolc, 2015.
- [5] ZHANG, Y.–EHLIG-ECONOMIDES, C. A.: Inflow Performance for a Hydraulic Fracture in a Deviated Well. In: paper SPE, 119345, 2009.